LOWER YUKON RIVER SONAR PROGRESS REPORT

1992

by

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and

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Regional Information Report[1] No. 3A93-05

Alaska Department of Fish and Game
Division of Commercial Fisheries
Chief Fisheries Scientist's Office
Sonar and Technical Services
333 Raspberry Road
Anchorage, Alaska 99518

April 1993

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PROJECT SPONSORSHIP

This project was partially supported by U.S./Canada Yukon River funds through Cooperative Agreement Number NA26FP0125-01.

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ACKNOWLEDGEMENTS

We thank crew-leader Randy Bachman and the crew of Janice Densham, Nathan Green, and John Snow for competently collecting the sonar and testfishing data reported herein; and Todd LaFlamme for assisting with site selection and sonar deployment.

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ABSTRACT

The Lower Yukon River Sonar Project operated for experimental purposes only during 1992 in order to assess the advantages and disadvantages of moving the sonar installation 0.5 km downriver. On the left bank, sonar could be deployed at the downriver site once the river recedes to typical mid-season water level. On the right bank, sonar could be deployed downriver at any time except during very high water levels in the spring, although the downriver site is somewhat less favorable for sonar than the traditional upriver site. Moving downriver would likely greatly improve the proportion of salmon detectable by shore-based sonar. For 1993, we recommend that the sonar be operated at the upriver site until mid-season, then moved downriver during the mid-season lull in fish passage.

KEY WORDS: salmon, *Oncorhynchus*, sonar, hydroacoustic, Yukon River, escapement

INTRODUCTION

Salmon *Oncorhynchus* are harvested for both commercial and subsistence purposes over more than 1,600 km of the Yukon River in Alaska and Canada. Management of the fishery requires in-season knowledge of run strength and escapement levels, information that is difficult to obtain in the Yukon River due to its large size, multiple channels, and turbid water. The Lower Yukon River Sonar Project[1] was initiated in 1985, and from 1986 through 1991, the project estimated daily migration of chinook salmon *O. tsawytscha*, summer- and fall-run chum salmon *O. keta*, and coho salmon *O. kisutch* from early June to early September. Single-beam, 420 kHz sonar was used to estimate total fish passage, and several sizes of gill nets were drifted to estimate species composition.

During 1992 the project operated for a shorter time (15 July to 5 August), and for experimental purposes only; daily fish passage estimates were not produced. Regular project operations were suspended so that two issues could be addressed: late-season passage of fish beyond the range of the sonar, and recent concern over a major technical shortcoming of 420 kHz sonar (attenuation).

Offshore Fish Passage

During the 1990 and 1991 seasons, substantial numbers of salmon were detected travelling far from shore, beyond the range of shore-based sonar. In response, transects with downward-looking sonar were initiated in 1990 to estimate offshore fish passage. Unfortunately, the transect estimates of fish passage were less precise than fixed sonar estimates and had other weaknesses as well (Fleischman et al. 1992). Late season passage estimates suffered in accuracy and precision because a relatively small proportion of fish could be detected from shore.

During the 1991 season, it became apparent that the shore-based sonar might detect a larger proportion of fish if it were moved approximately 0.5 km downriver. Here, the river narrows from 970 m to less than 600 m wide, and transect data indicated that fish travelling along the left bank were closer to shore than at the upriver site. However the feasibility of deploying sonar at the new site, as well as the likelihood of finding an acceptable bottom profile, had not yet been tested.

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[1] The Lower Yukon River Sonar Project was referred to in previous reports as the Yukon River Sonar Project. The new designation distinguishes it from a new sonar installation on the upper Yukon River at Eagle.

Attenuation

Sonar signals at 420 kHz exhibit an uncorrected reduction of sound intensity with range (Skvorc, Alaska Department of Fish and Game, Anchorage, personal communication). Such attenuation of the sonar signal seriously compromises salmon passage estimates in two ways. First, the attenuated 420 kHz sonar beam ensonifies a smaller proportion of the river than previously assumed, causing fish passage to be underestimated. Second, attenuation prevents use of voltage thresholds to exclude small fish from detection. When the sonar signal attenuates with range, the effect of a voltage threshold also varies with range. If a threshold is set to exclude fish smaller than, for example, 450 mm at 20 m range, fish larger than 450 mm would be excluded at ranges greater than 20 m. As a result, very low thresholds are necessary to avoid excluding salmon at long ranges, in turn causing very small fish to be detected at short ranges. Consequently, gillnets of many mesh sizes must be drifted in order to estimate species composition.

Concern about these shortcomings of 420 kHz sonar prompted preparations to convert to 120 kHz, a frequency which attenuates very little in freshwater (MacLennan and Simmonds 1992). Changing to a different frequency entails converting echo sounders to 120 kHz and obtaining 120 kHz transducers. The 120 kHz transducers had to be specially manufactured and were not scheduled to be available until mid-season 1992. Rather than operate at 420 kHz again in 1992, regular project operations were suspended, and the resources thus saved were used to acquire the 120 kHz equipment. An abbreviated agenda was adopted for 1992, with the following objectives established pre-season.

(1) To deploy the left and right-bank sonar slightly downriver of the traditional sites, and to assess the relative merits of operating the sonar at the new versus old locations.

(2) After receipt of new transducers in mid-season, to collect sufficient 120 kHz dual-beam data to permit post-season estimation of an appropriate voltage-threshold to exclude cisco and small whitefish from detection by sonar. Unfortunately the new 120 kHz dual-beam transducers did not arrive in time, and we were unable to address this objective.

METHODS

Hydroacoustic Sampling

Equipment

Sonar equipment included Biosonics[1] models 101 and 105 echo sounders configured to transmit and receive at either 420 kHz or 120 kHz, one single-beam 4° circular 120 kHz transducer manufactured by Acoustic Transducers International (A.T.I.)[1], one 6° circular and two 4° X 15° elliptical Biosonics[1] single-beam 420 kHz transducers, two Hydroacoustics Technology Inc.[1] chart recorder interfaces coupled with two dot matrix printers, and a Hewlett-Packard[1] model 54501A digital storage oscilloscope. Transducers were remotely aimed using Biosonics[1] and Remote Ocean Systems[1] dual-axis rotators mounted on metal tripods. Gasoline generators (650 W to 3500 W) supplied 110 VAC power. A Lowrance[1] X-15 fathometer was used to investigate bottom profiles and for bank-to-bank transects. Transect data were digitized using a 12" x 18" Summagraphics[1] graphics tablet.

Sample Design

On the right bank, sonar data were collected at the site used in 1986-1991, designated here as "upriver"; and at a new "downriver" site at the base of the bluffs below camp (Figure 1). On 22-27 July, data were collected from the downriver site only; on 1-5 August, data were collected from both the upriver and downriver sites.

On the left bank, sonar data were collected on 20-22 July at an upriver site used in 1991, and from 24 July to 5 August at a new downriver site (Figure 1). In addition, the sonar was operated roughly midway between the two sites on 15-18 July. Equipment limitations prevented us from deploying sonar at more than one location at a time on the left bank.

Data collection proceeded similarly to 1991 (Fleischman et al. 1992) but with reduced sampling intensity. Unless other objectives interfered, the sonar was operated during two 2-3 hour periods daily (morning and afternoon/evening). Number of upstream targets was recorded, by range sector, every 15 minutes.

During 1-5 August, to compare magnitude and range distribution of fish passage at the two right-bank sites, data were collected from upriver and downriver transducers during alternating 15

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[1] Use of a company's name does not constitute endorsement.

minute subsamples. Similar equipment was used at both sites: 420 kHz 6° circular transducers, Biosonics[1] rotators, and 305-meter cables. Although the two tripods were roughly 500 m apart, both transducers were connected by cable to the same sounder and chart recorder in a tent midway between the two sites.

Between 23 and 31 July, we performed 62 bank-to-bank transects (7-12 daily on six different days) with downward-looking sonar to estimate the spatial distribution of migrating fish. Chum passage declined during this period, and on 1 August transects were discontinued. A large pulse of chum salmon passed through on 4-5 August, during which time 32 additional transects were completed. Transect chart recordings were digitized to record the relative locations of targets, left and right banks, and deepest point of the river channel. From this information, depth and distance from shore were calculated for each target.

The results of 79 transects performed 9-23 August 1991 at the downriver site, but not analyzed in the 1991 report (Fleischman et al. 1992), are also reported here.

Test-fishing

Gill nets were drifted through or near sonar ranges on each bank to provide an additional index of fish abundance and to monitor species composition. Seven different mesh sizes were utilized: 2.75" (70 mm), 4" (102 mm), 5" (127 mm), 5.5" (140 mm), 6.5" (165 mm), 7.5" (191 mm), and 8.5" (216 mm). All nets were 25 fathoms (45.7 m) long and 7.6 m deep, and were constructed of Momoi[1] MTC-50 or MT-50 multifilament nylon twine. Hanging ratio was 2:1.

A total of 154 drifts were conducted between 15 July and 5 August, in four different locations: (1) right-bank downriver site, along the bluff, (2) right-bank upriver site (same location as 1991), (3) left-bank nearshore (behind the sonar transducer), and (4) left-bank offshore (in sonar range). Two to twelve drifts, in two to four locations, were completed daily. All drifts with one net were completed before switching to the next net; drifts were done on alternate banks so there was a minimum of 20 minutes between drifts on a given bank.

Four times were recorded for each drift: net start out (net starting out of boat, SO), net full out (FO), net start in (SI), and net full in (FI). Drift time was calculated as (FO-SO)/2 + (SI-FO) + (FI-SI)/2. Captured fish were identified to species and measured for length (salmon species mid-eye to tail fork, non-salmon species snout to tail fork).

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Analytical Methods

Transect data were collected during 1-2 hour blocks daily, with different numbers of targets detected during each block. Data were pooled over all days for presentation in graphs and to calculate proportions of targets within spatial zones (e.g., within shore-based sonar range versus beyond sonar range). For statistical purposes, the daily group of transects was the unit of replication, and the targets detected during each daily group were a cluster sample (targets were clustered in time). Therefore, standard errors of transect data proportions were calculated following Cochran (1977:66), i.e., each squared deviation of a daily proportion from the overall pooled proportion was weighted by the total number of targets detected on that day.

Testfish data were treated similarly for statistical purposes. The daily testfish period was the unit of replication, and the fish caught during each period were a cluster sample. Standard errors of testfish proportions were also calculated following Cochran (1977:66), with each squared deviation weighted by the total number of fish caught on that day.

RESULTS AND DISCUSSION

Sonar Site Evaluation: Left Bank

Sonar Deployment: High Water Conditions

The river was unusually high when we arrived on 8 July. On 11-12 July, to look for potential new sonar sites, bottom profiles were recorded at regular intervals perpendicular to the left bank. Near the 1991 left-bank sonar camp (Figure 1), a bar begins near shore and widens downstream. Though the water level had been falling steadily since our arrival (Figure 2), in mid-July the bar was still submerged under two or more meters of water. As a result the bottom profile at the narrowest section of the river was irregular and channeled near shore, and convex further out (Figure 3a). Installing sonar at the narrow point during high water would have required deploying the tripod far offshore in order to find a constant bottom slope. Tripod deployment more than 50-60 m from shore was not feasible in mid-July due to deep water and fast current.

More suitable profiles, given the high water level, were found upriver. We deployed sonar near the 1991 left-bank sonar camp from 15 to 18 July and near the 1991 sonar site from 20 to 22 July (Figure 3b,c). At both locations, the bottom slope was constant but not quite steep enough to accommodate the 4° 120 kHz beam.

Sonar Deployment: Low Water Conditions

By 24 July the river had fallen another meter (Figure 2), and water velocity near shore had slowed considerably. On 24 July we were able to deploy a tripod over 100 m from shore at the left-bank downriver site (Figure 1).

Sonar deployment at this location was workable, though not trouble-free. We detected fish over 120 m from the transducer, i.e., more than 220 m from shore. Bottom could often be detected out to 70 m and beyond; although repeated movements of the tripod were usually required to obtain a good aim. Aim often deteriorated rapidly after deployment, presumably due to settling of the tripod and/or dynamic erosion and deposition of bottom sediments. Surprisingly, we had few problems with cables becoming embedded in bottom sediments. We freed the cable (lifted it off the bottom along its full length) every day or two, and this proved sufficient to prevent it from becoming irretrievably buried.

Data were collected during periods of both low and high salmon passage rates. Catches of salmon in testnets were small by the time we deployed sonar at the downriver site on 24 July.

Catches continued to decline and had come to a virtual standstill by 3 August (Table 2). Fortuitously, chum salmon passage increased dramatically on 4 August, and we collected two days of data before our scheduled departure on 6 August.

Bank-to-Bank Transect Results. Transect data from 1992, though limited, suggest that the 120 kHz transducer deployed at the downriver site detected a large proportion of left-bank oriented fish. Seventy-six transects between 23 July and 5 August detected a total of 55 targets between the left bank and the river thalweg (deepest part of the river channel, 200 m from the right- bank shore). Of these, four (7%) were behind the transducer, 44 (80%) were within sonar range, and seven (13%) were beyond sonar range.

These results agree with those obtained from 79 transects at the downriver site during 9-23 August 1991. We did not deploy shore-based sonar downriver in 1991, but if we had had the same configuration as in 1992 (total range beyond mud bar = 220 m), then 82 $\pm$ 3.3% (s.e.) of 203 targets between the left bank and the thalweg would have been within sonar range (Figure 4).

The downriver site is a clear improvement over the upriver site in this respect. The river is 970 m wide at the upriver site, and the thalweg is located 770 m from the left-bank shore and 200 m from the right-bank shore. During fall 1991, total left-bank sonar range at the upriver site was 161 m, with one onshore and one offshore transducer, both 420 kHz. During those days when comparable data were available from the downriver site (9-23 August 1991), transects at the upriver site detected 312 targets between the left bank and the thalweg. Of these, only 30 $\pm$ 4.6% were within 161 m of shore (Figure 4). Using 120 kHz sonar, and assuming that a suitable bottom profile could be found, fish could be detected at greater ranges. Still, even with a total sonar range of 220 m (comparable to downriver site in 1992), only 43 $\pm$ 5.2% of targets would have been detected. To detect 80% of left-bank targets from shore, as may be achievable at the downriver site, the upriver site would have required a total sonar range of >430 m.

Testfishing Results. The zone between the offshore transducer and the left bank may be somewhat difficult to ensonify at the downriver site due to an uneven bottom profile (Figure 3a). However testfishing between the left-bank transducer and shore indicate that a relatively small number of chum salmon migrate through this zone. From 26 July to 5 August, gillnets were drifted in each of two left-bank strata: 1) "nearshore" between the transducer and shore and 2) "offshore" beyond the transducer in sonar range. A total of 44 drifts were done with salmon-sized nets (5.0", 5.5", 6.5", and 7.5"), 22 in each stratum. Of 74 chum salmon and 1 coho salmon captured, only 12 (16.0 $\pm$ 6.6% [s.e.]) were caught in the nearshore stratum.

Sonar Site Evaluation: Right Bank

The right-bank shore forms a rocky bluff, 30-40 m high, immediately downstream from camp. The river narrows abruptly at this point and water velocity is rapid. Along the bluff, sheer bedrock outcrops alternate with less-steep talus slopes. We deployed sonar at the talus slope nearest camp on 22 July, and were able to detect bottom, at intervals, to >165 m range. As best as could be determined with the Lowrance in the fast current, bottom profiles also appeared favorable at any of the other talus slopes along the bluff. Sonar deployment would be logistically feasible on any talus slope, but much more difficult on bedrock outcrops.

Sonar Results

The sonar detected very few fish when operating at the downriver right-bank site on 22, 23, or 27 July, no matter what beam width, frequency, aim, or chart speed we used. On 1 August, we deployed 6° circular 420 kHz transducers at both downriver and the upriver (1991) right-bank sites and collected alternating 15-minute samples at the upriver and downriver sites for four days. Maximum range was 80 m.

On 1-2 August, as indicated by testfishing results (Table 1), there were few chum salmon migrating past the sonar site, but on 4-5 August chum passage increased substantially. No data were collected on 3 August. During low salmon passage (1-2 August), right-bank fish were distributed unimodally over range, with the highest abundance within 10 m of the transducer. During high salmon passage (4-5 August), fish were distributed bimodally; abundance was still greatest within 10 m of the transducer, but there was a second, smaller peak between 50 and 60 m (Figure 5). During high salmon passage sonar at the upriver site counted 41.7 $\pm$ 9.2 (99% C.I.) more fish per hour than did sonar at the downriver site, but during low salmon passage there was no difference (Student's $t = 1.16$, 2 df, $P > 0.10$; Figure 5).

Transect Results

When chum abundance increased on 4-5 August 1992, fish passage rate at the upriver site increased more than at the downriver site (non-statistical comparison; Figure 5), suggesting that more chum salmon swam by the upriver site than the downriver site. This is worrisome in that it raises the possibility that chum salmon may cross the river from the left to the right bank between the two sites. The upriver site is located roughly 500 m upstream of the downriver site (Figure 1). However 1991 bank-to-bank transect data show no evidence of cross-over; horizontal distribution of targets was similar between sites. Proportion of targets to the right of mid-river was comparable between sites (0.365 downriver, 0.39 upriver), as was the proportion of targets to the right of the thalweg (0.32 downriver, 0.29 upriver).

Transect data from 1991 may also explain why sonar at the right-bank downriver site apparently missed salmon (Figure 5); salmon at the upriver site may be travelling closer to shore than at the downriver site, with a greater proportion within the 80 m range of 420 kHz sonar. During 9-23 August 1991 there were three days of high salmon abundance, according to testfish CPUE: 9, 10 and 23 August. On these days, 47 of 70 targets (67 $\pm$ 3.6%) were within 80 m at the upriver site, compared to only 33 of 70 targets (47 $\pm$ 12.5%) within range at the downriver site. The difference between sites was not significant ($P > 0.10$). We report it anyway because (1) the small sample size ($n = 3$ days) weakened the power of the comparison, and (2) it suggests an explanation for the discrepancy between sonar counts at right-bank sites (Figure 5).

Even if salmon swim further offshore at the downriver site, the vast majority would be within 120 kHz sonar range. The bottom slopes evenly almost to the thalweg (at 200 m) at both sites, and would be suitable for sonar out to 160 m or more. Approximately 90% of right-bank transect targets were within 160 m of shore at either site, regardless of salmon abundance.

Testfishing Results

Salmon-sized meshes (5.0", 5.5", 6.5", 7.5") were drifted at each of the two right-bank sites eight times during 1-5 August 1992, yielding inconclusive results. Seventeen chum salmon were caught, seven at the upriver site and ten at the downriver site. Eight of the ten chum caught at the downriver site were caught on one drift. The downriver site was more difficult to fish because of high water velocity.

Equipment

Though the two sonar systems had similar components (see METHODS), the upriver system produced far more electronic interference (with the transmitter disabled) than the downriver system. In the process of trying to isolate the source of the noise, generators and transducer cables were (crudely) tested for noise production and shielding capabilities. With the transmitter disabled and other equipment and settings held constant, interference produced by four Honda generators varied in voltage by a factor of 20. A 650 W generator produced the least noise, and one of two 1600 W generators produced the most. Interference was also measured on four transducer cables, all of which were 305 m long. Again, all other equipment and settings were held constant. Interference voltage was uniformly low for three of the cables but four to seven times higher for the fourth. To produce substantial interference required both a noisy generator and a faulty cable; noise could be reduced considerably by replacing either.

CONCLUSIONS AND RECOMMENDATIONS

Sonar deployment is logistically feasible on both right and left banks at the narrow section of the river immediately below the sonar camp. On the right bank, a tripod could be deployed at any of the talus slopes along the bluff except during very high water in early spring. On the left bank, a mud bar extending >50 m from shore prevents us from obtaining a suitable bottom profile during the early season. But as the river recedes to typical mid-season level and the current slows near shore, a tripod can be deployed >100 m offshore. In 1992, this enabled us to reach a site with a good bottom profile, which apparently had few salmon passing behind the transducer. The sonar could be moved, at least temporarily, to any site on the left or right bank with a minimal investment of time (2-3 days maximum) and materials. The 4° 120 kHz single-beam transducer proved too wide for some installations on the left bank; a 2° or 2.5° transducer may be needed at times.

Given continued favorable bottom profiles, the left-bank downriver site offers one very clear advantage over the upriver site during the late season: the ability to ensonify a much higher proportion of passing salmon with the shore-based sonar. This would greatly reduce the uncertainty (due to poor precision and accuracy) associated with fall chum salmon and coho salmon passage estimates. Disadvantages of moving the left-bank sonar in mid-season include (1) uncertainty as to whether a suitable profile will be available, or would persist, given the dynamic nature of the left-bank bottom topography, (2) more logistical problems associated with deploying a tripod far offshore on a somewhat-unstable substrate, and (3) potential difficulties counting or monitoring salmon passage behind the sonar transducer.

On the right bank, the downriver site appears to be slightly less favorable than the existing upriver site. Deploying the tripod and laying out cable is more difficult at the downriver site because of the steepness of the bluff. Testfishing is also more difficult because of the rapid current. Finally, 1992 data suggest that salmon were less easily detected by sonar at the downriver site than at the upriver site (Figure 5), although other explanations exist for the discrepancy. Salmon may swim further offshore at the downriver site, out of 420 kHz sonar range but still within 120 kHz sonar range. Alternatively, the two transducers used in 1992, though of the same make and model, may have differed in sensitivity.

Keeping the two sonar installations directly across from one another is desirable in order to minimize the probability of salmon crossing the river between sites and being counted twice or not at all. Therefore, location of the left-bank sonar factors heavily into where to install the right-bank sonar. If the left-bank sonar is deployed at the downriver site, the disadvantages of the right-bank downriver site may be outweighed by the benefits of keeping the two sonar installations more nearly across from each other.

Our recommendations are as follows:

- ▸Use the traditional upriver sites, left and right banks, during the early season. Salmon apparently run closer to shore then and upriver profiles are better during high water. Periodically use a fathometer or other downward-looking sonar to do bank-to-bank transects upriver and bottom profiles downriver.

- ▸If water level and bottom profiles are favorable, move the left-bank sonar to the downriver site during the expected mid-July lull in salmon passage. This would potentially put a much larger proportion of fish within reach of the sonar, more than compensating for possible logistic difficulties. If bottom profiles become unusable or if unforeseen problems arise, the sonar could be moved back to the old upriver site with minimal loss of time and data.

- ▸Move the right-bank site downriver if and when the left-bank site is moved. There are no compelling reasons to move the right-bank sonar other than to eliminate the possibility of fish crossing over between sites. If sonar is deployed at the new downriver site during late-season, continue to collect simultaneous 120 kHz data at the upriver site until it can be reasonably established that sonar at the new site is not missing substantial numbers of salmon. Both sites can be controlled from the same sounder in a centrally located shelter.

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MacLennan, D.N. and E.J. Simmonds. 1992. Fisheries Acoustics. London: Chapman and Hall. 325 pp.

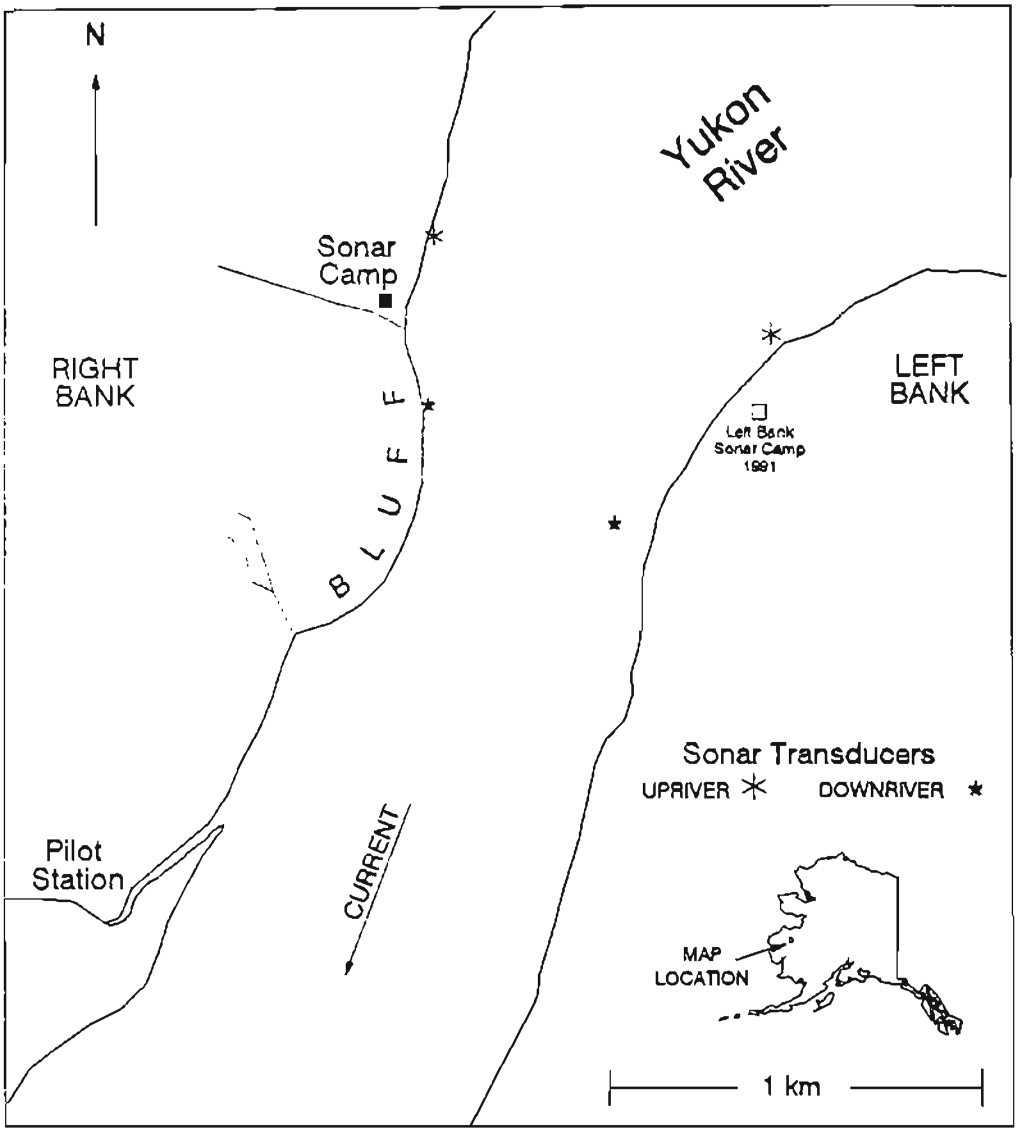


Figure 1 Lower Yukon River sonar sites and vicinity. Upriver transducer locations are the same as those used in 1991.

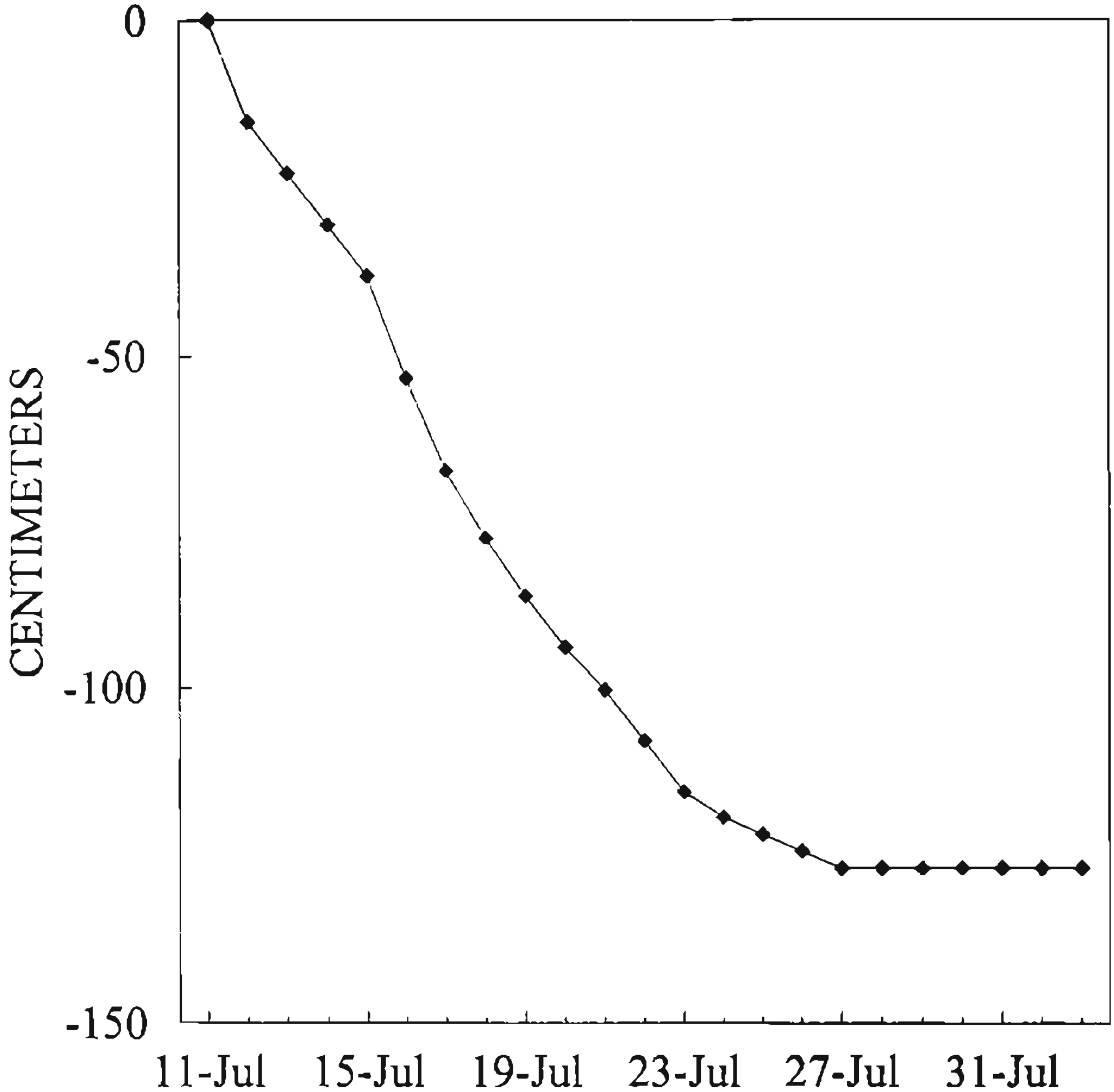
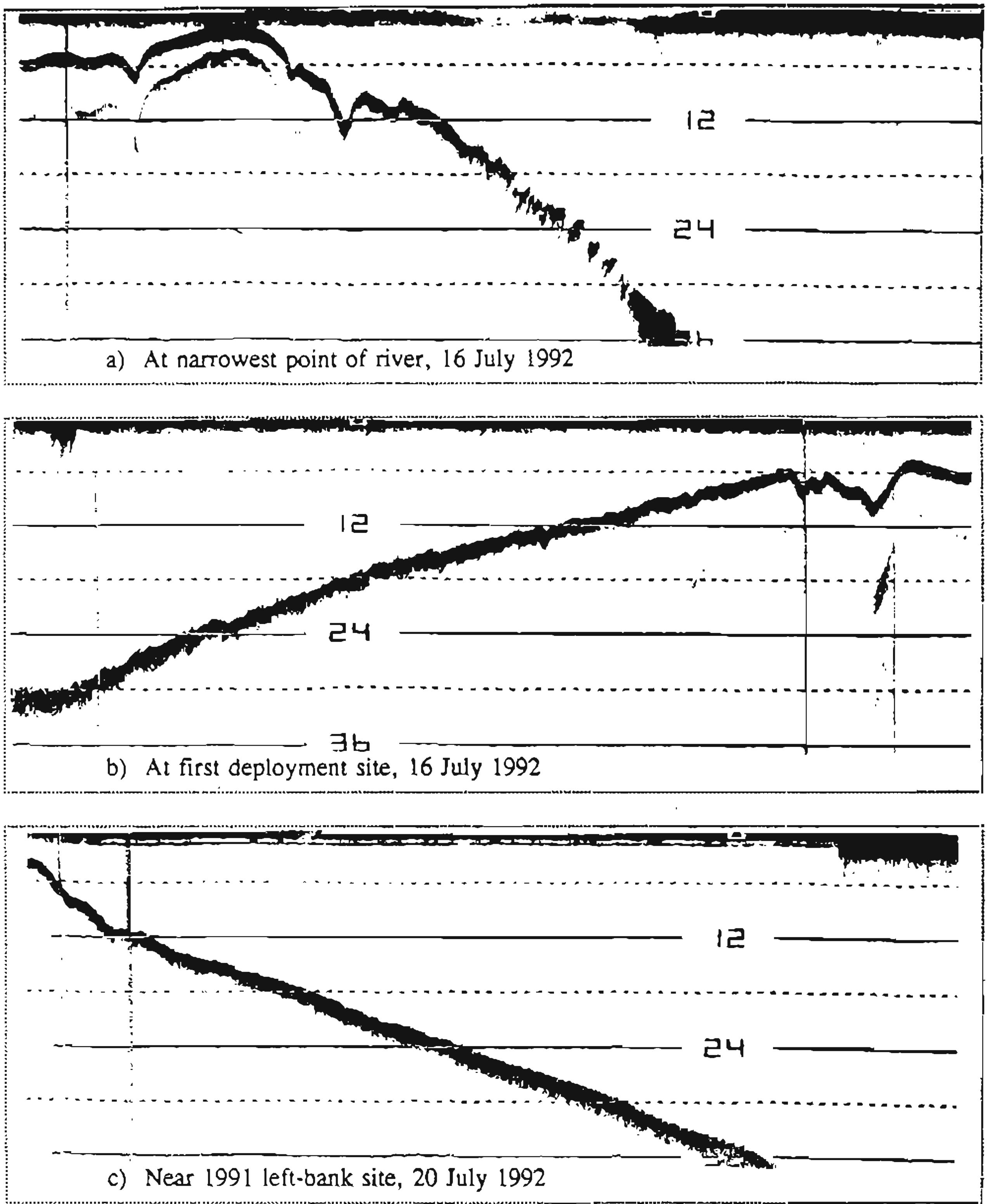


Figure 2 Relative water level, Yukon River near Pilot Station, 1992.



a) At narrowest point of river, 16 July 1992

b) At first deployment site, 16 July 1992

c) Near 1991 left-bank site, 20 July 1992

Figure 3 Bottom profiles at the three left-bank sites used in 1992.

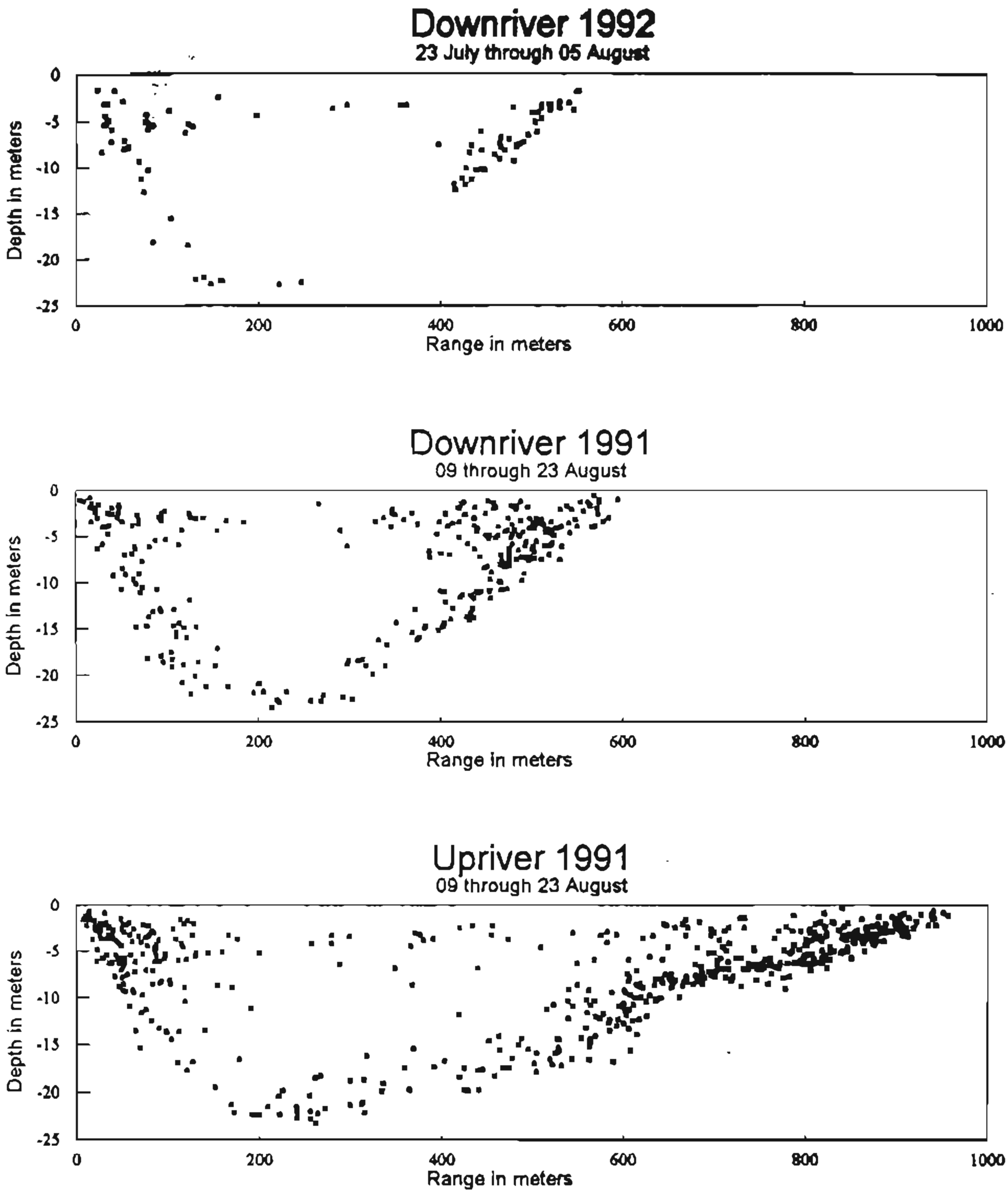
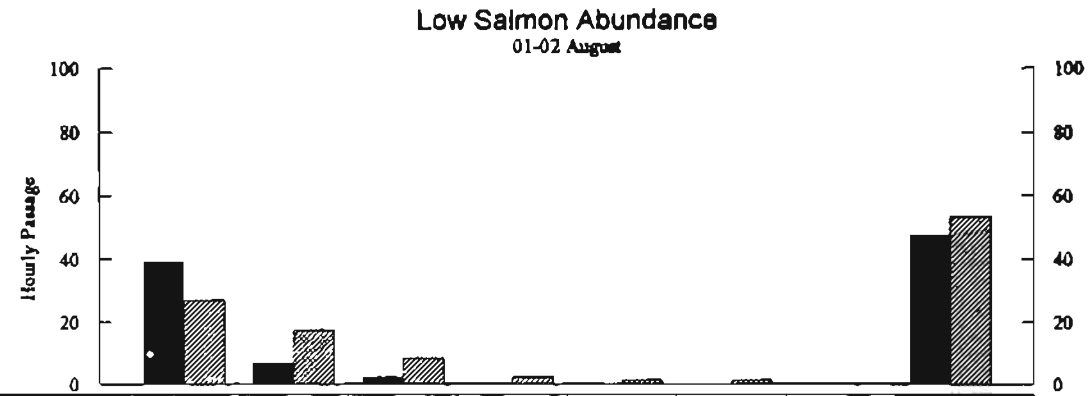
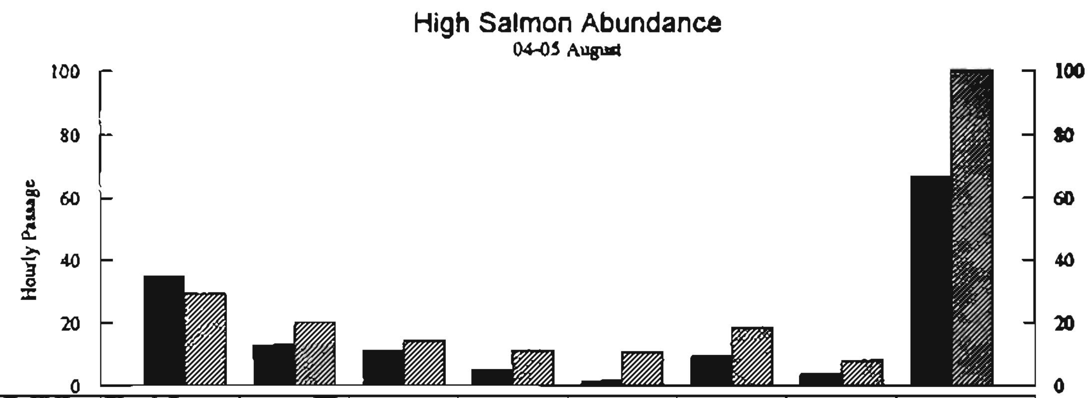


Figure 4 Location of targets detected during bank-to-bank transects with downward-looking sonar, lower Yukon River 1991-1992.



Range in meters	0-10	10-20	20-30	30-40	40-50	50-60	60-70	TOTAL
New Site	39.0	6.7	2.3	0.3	0.0	0.0	0.0	47.7
Old Site	27.0	17.3	8.3	2.3	1.3	1.3	0.0	53.3

Right Bank, upstream targets only



Range in meters	0-10	10-20	20-30	30-40	40-50	50-60	60-70	TOTAL
New Site	35.0	13.3	11.3	5.3	1.8	9.5	4.0	66.8
Old Site	29.3	20.3	14.5	11.3	10.8	18.5	8.0	101.0

Right Bank, upstream targets only

Figure 5 Range distribution of right-bank targets detected by 420 kHz sonar, lower Yukon River 1992.

Table 1. Results of testfishing, Lower Yukon River Sonar 1992, one line per drift.

DATE	STARTOUT	MESH	STRAT[a]	METHOD	MINUTES FISHING TIME	CHINOOK	JACK	CHUM	COHO	PINK	SHEEFISH	WHITE	CISCO
15JUL	10:53	2.75	4	D	10.7	.	.	.	.	.	.	.	.
15JUL	11:08	2.75	2	D	8.6	.	.	1	.	1	.	.	2
15JUL	11:29	4.00	4	D	10.8	.	.	2	.	.	.	.	.
15JUL	11:45	4.00	2	D	11.3	.	2	1	.	19	.	1	.
15JUL	12:21	5.50	4	D	11.1	.	.	13	.	1	.	.	.
15JUL	12:46	5.50	2	D	7.0	.	.	9	.	23	.	.	.
16JUL	12:40	2.75	4	D	12.0	.	.	1	.	.	.	.	.
16JUL	12:59	2.75	2	D	11.3	.	.	.	.	2	.	.	.
16JUL	13:24	4.00	4	D	12.1	.	.	3	.	.	.	.	.
16JUL	13:47	4.00	2	D	10.6	.	.	.	.	.	.	.	.
16JUL	13:47	5.00	4	D	10.3	.	.	10	.	1	.	.	.
16JUL	14:12	5.00	2	D	6.2	.	.	22	.	23	.	.	.
16JUL	16:17	7.50	2	D	9.9	.	.	4	.	1	.	.	.
16JUL	16:33	7.50	4	D	9.9	.	.	6	.	.	.	.	.
16JUL	17:04	8.50	4	D	11.0	.	.	2	.	.	.	.	.
16JUL	17:23	8.50	2	D	6.9	.	.	2	.	1	.	.	.
20JUL	17:41	5.50	4	D	9.8	.	.	4	.	.	.	.	.
20JUL	18:01	5.50	3	D	8.0	.	.	1	.	2	.	1	.
21JUL	10:48	2.75	3	D	3.9	.	.	1	.	.	.	.	2
21JUL	11:03	2.75	1	D	5.3	.	.	.	.	.	.	.	.
21JUL	11:14	2.75	4	D	6.9	.	.	1	.	1	.	.	.
21JUL	11:36	5.00	3	D	6.5	.	.	.	.	2	.	.	.
21JUL	11:49	5.00	1	D	5.5	.	.	.	.	1	.	.	.
21JUL	12:03	5.00	4	D	11.1	.	.	.	.	.	.	.	.
22JUL	9:47	4.00	3	D	6.6	.	.	.	.	.	.	.	.
22JUL	9:57	4.00	4	D	6.1	.	.	.	.	.	.	.	.
22JUL	10:08	4.00	1	D	4.6	.	.	.	.	.	.	.	.
22JUL	10:31	5.50	3	D	6.0	.	.	11	.	1	.	.	.
22JUL	10:53	5.50	4	D	7.4	.	.	.	.	.	.	.	.
22JUL	11:04	5.50	1	D	5.8	.	.	1	.	.	.	.	.
22JUL	11:22	7.50	4	D	6.9	.	.	4	.	.	.	.	.
22JUL	11:39	7.50	3	D	6.2	.	.	1	.	.	.	.	.
22JUL	11:49	7.50	1	D	5.7	.	.	1	.	.	.	.	.
23JUL	10:02	2.75	5	D	15.0	.	.	1	.	.	.	.	10
23JUL	10:26	2.75	1	D	5.3	.	.	.	.	.	.	.	.
23JUL	10:49	4.00	5	D	6.5	.	.	1	.	1	.	.	.
23JUL	11:02	4.00	1	D	4.5	.	.	.	.	.	.	.	.
23JUL	11:20	5.00	5	D	6.1	.	.	1	.	.	.	.	.
23JUL	11:31	5.00	1	D	5.6	.	.	1	.	.	.	.	.
23JUL	11:52	5.50	5	D	6.9	.	.	3	.	.	.	.	.
23JUL	12:06	5.50	1	D	5.0	.	.	.	.	.	.	.	.
23JUL	12:27	6.50	5	D	7.4	.	.	2	.	1	.	.	.
23JUL	12:39	6.50	1	D	5.7	.	.	.	.	.	.	.	.
24JUL	12:06	6.50	4	D	7.7	.	.	7	.	.	.	.	.
24JUL	12:26	6.50	1	D	7.8	.	.	.	.	.	.	.	.
24JUL	12:46	2.75	4	D	7.1	.	.	.	.	.	.	.	.
24JUL	12:56	2.75	1	D	5.4	.	.	.	.	.	.	.	.
24JUL	13:10	5.50	4	D	9.8	.	.	4	.	1	1	.	.
24JUL	13:30	5.50	1	D	7.0	.	.	.	.	1	.	.	.
24JUL	13:58	5.00	4	D	7.7	.	.	1	.	1	.	.	.
24JUL	14:10	5.00	1	D	5.7	.	.	1	.	1	.	.	.
24JUL	14:25	7.50	4	D	11.7	.	.	3	.	.	.	.	.
24JUL	14:44	7.50	1	D	6.3	1	.	1	.	.	.	.	.

[a] Stratum: 1 = right bank downriver, 2 = right bank upriver, 3 = left bank onshore, 4 = left bank offshore

Table 1. Page 2 of 3.

DATE	STARTOUT	MESH	STRAT[a]	METHOD	MINUTES FISHING TIME	CHINOOK	JACK	CHUM	COHO	PINK	SHEEFISH	WHITE	CISCO
26JUL	15:37	5.50	4	D	8.3	.	.	7	.	.	.	.	.
26JUL	15:53	5.50	3	D	4.5	.	.	.	.	.	.	1	.
26JUL	16:11	5.50	4	D	6.7	.	.	.	.	.	.	.	.
26JUL	16:30	2.75	3	D	5.4	.	.	.	.	1	.	.	.
27JUL	9:13	4.00	3	D	13.6	.	.	.	.	1	.	.	1
27JUL	9:33	4.00	1	D	6.9	.	.	1	.	1	.	.	.
27JUL	9:44	4.00	4	D	9.9	.	.	.	.	.	.	.	.
27JUL	10:06	5.50	3	D	9.3	.	.	.	.	3	.	5	.
27JUL	10:25	5.50	1	D	7.9	.	.	1	.	3	.	.	.
27JUL	10:42	5.50	4	D	9.8	.	.	.	.	.	.	.	.
27JUL	11:12	7.50	3	D	9.2	.	.	.	.	.	.	.	.
27JUL	11:25	7.50	1	D	4.6	.	.	.	.	.	.	.	.
27JUL	11:34	7.50	4	D	9.2	.	.	1	.	.	.	.	.
28JUL	14:24	2.75	3	D	7.5	.	.	.	.	.	.	.	1
28JUL	14:37	2.75	1	D	4.7	.	.	.	.	1	.	.	.
28JUL	14:48	2.75	4	D	10.5	.	.	.	.	.	.	.	.
28JUL	15:11	5.00	3	D	7.8	.	.	.	.	.	.	.	.
28JUL	15:22	5.00	1	D	4.8	.	.	1	.	.	.	.	.
28JUL	15:31	5.00	4	D	8.8	.	.	3	.	.	.	1	.
28JUL	15:57	6.50	3	D	10.1	.	.	.	.	.	1	.	.
28JUL	16:11	6.50	1	D	6.1	.	.	1	.	.	.	.	.
28JUL	16:22	6.50	4	D	8.2	.	.	2	.	.	.	.	.
28JUL	16:54	7.50	3	D	6.5	.	.	.	.	.	.	.	.
28JUL	17:05	7.50	1	D	4.8	.	.	.	.	.	.	.	.
28JUL	17:14	7.50	4	D	11.1	.	.	.	.	.	.	.	.
29JUL	14:19	7.50	3	D	8.1	.	.	1	.	1	.	.	.
29JUL	14:32	7.50	1	D	4.9	.	.	.	.	.	.	.	.
29JUL	14:39	7.50	4	D	10.3	.	.	.	.	.	.	.	.
29JUL	15:03	6.50	3	D	7.3	.	.	.	.	.	.	.	.
29JUL	15:14	6.50	1	D	4.6	.	.	.	.	.	.	.	.
29JUL	15:22	6.50	4	D	9.0	.	.	.	.	.	.	.	.
29JUL	15:37	5.50	3	D	9.0	.	.	1	.	.	.	3	.
29JUL	16:01	5.50	1	D	5.4	.	.	.	.	1	.	.	.
29JUL	16:12	5.50	4	D	7.9	.	.	.	.	.	.	.	.
29JUL	16:33	4.00	3	D	10.2	.	.	.	.	.	.	3	.
29JUL	16:49	4.00	1	D	5.2	.	.	.	.	1	.	.	.
29JUL	16:59	4.00	4	D	10.3	.	.	.	.	.	.	.	.
30JUL	14:30	4.00	3	D	10.5	.	.	.	.	.	.	5	.
30JUL	14:48	4.00	1	D	4.5	.	.	.	.	.	.	.	.
30JUL	14:56	4.00	4	D	8.1	.	.	.	.	.	.	.	.
30JUL	15:16	2.75	3	D	9.5	.	.	.	.	.	.	.	5
30JUL	15:31	2.75	1	D	5.9	.	.	.	.	.	.	.	.
30JUL	15:41	2.75	4	D	8.9	.	.	.	.	.	.	.	.
30JUL	16:05	5.50	3	D	9.9	.	.	.	.	1	.	4	.
30JUL	16:23	5.50	1	D	4.7	.	.	.	.	.	.	.	.
30JUL	16:32	5.50	4	D	10.1	.	.	4	.	.	.	3	.
30JUL	17:01	7.50	3	D	7.8	.	.	.	.	.	.	.	.
30JUL	17:12	7.50	1	D	4.0	.	.	.	.	.	.	.	.
30JUL	17:20	7.50	4	D	13.7	2	.	1	.	1	.	.	.
31JUL	14:21	7.50	3	D	10.1	.	.	1	.	1	.	.	.
31JUL	14:37	7.50	1	D	5.2	.	.	.	.	.	.	.	.
31JUL	14:47	7.50	4	D	10.0	.	.	.	.	.	.	.	.
31JUL	15:11	6.50	3	D	10.6	.	.	1	.	1	.	.	.
31JUL	15:26	6.50	1	D	5.1	.	.	.	.	.	.	.	.

[a] Stratum: 1 = right bank downriver, 2 = right bank upriver,
3 = left bank onshore, 4 = left bank offshore

Table 1. Page 3 of 3.

DATE	STARTOUT	MESH	STRAT[a]	METHOD	MINUTES FISHING TIME	CHINOOK	JACK	CHUM	COHO	PINK	SHEEFISH	WHITE	CISCO
31JUL	15:35	6.50	4	D	10.6	.	.	.	.	.	.	.	.
31JUL	16:02	5.00	3	D	7.8	.	.	1	.	.	.	1	.
31JUL	16:15	5.00	1	D	5.5	.	.	.	.	.	.	.	.
31JUL	16:23	5.00	4	D	9.7	.	.	1	.	.	.	1	.
31JUL	16:47	2.75	3	D	9.1	.	.	.	.	.	.	.	2
31JUL	17:02	2.75	1	D	4.5	.	.	.	.	1	.	.	.
31JUL	17:10	2.75	4	D	8.0	.	.	.	.	.	.	.	.
01AUG	14:11	2.75	3	D	10.9	.	.	.	.	.	.	3	7
01AUG	14:33	2.75	2	D	9.7	.	.	.	.	2	.	.	9
01AUG	14:52	2.75	4	D	8.4	.	.	.	.	.	.	.	.
01AUG	15:05	2.75	1	D	5.0	.	.	.	.	.	.	.	.
01AUG	15:50	5.00	3	D	10.3	.	.	.	.	.	.	.	.
01AUG	16:05	5.00	2	D	8.9	.	.	.	.	3	.	1	.
01AUG	16:22	5.00	4	D	12.1	.	.	.	.	.	.	.	.
01AUG	16:38	5.00	1	D	4.8	.	.	.	.	.	.	.	.
01AUG	17:00	7.50	3	D	8.3	.	.	.	.	.	.	.	.
01AUG	17:13	7.50	2	D	5.5	.	.	.	.	.	.	.	.
01AUG	17:22	7.50	4	D	10.8	.	.	.	.	.	.	.	.
01AUG	17:36	7.50	1	D	4.6	.	.	.	.	.	.	.	.
02AUG	14:01	6.50	3	D	8.1	.	.	.	.	.	.	.	.
02AUG	14:14	6.50	2	D	14.4	.	.	.	.	1	.	.	.
02AUG	15:04	6.50	4	D	8.3	.	.	.	.	.	.	.	.
02AUG	15:15	6.50	1	D	4.0	.	.	.	.	.	.	.	.
02AUG	15:34	5.00	3	D	8.3	.	.	.	.	.	.	.	.
02AUG	15:46	5.00	2	D	9.2	.	.	1	.	.	.	1	.
02AUG	16:01	5.00	4	D	10.5	.	.	.	.	1	.	.	.
02AUG	16:16	5.00	1	D	5.0	.	.	.	.	.	.	.	.
02AUG	16:33	2.75	3	D	8.9	.	.	.	.	.	.	.	1
02AUG	16:46	2.75	2	D	5.8	.	.	.	.	.	.	.	2
02AUG	16:57	2.75	4	D	10.6	.	.	.	.	.	.	.	.
02AUG	17:12	2.75	1	D	4.5	.	.	.	.	.	.	.	.
04AUG	17:54	6.50	3	D	6.5	.	.	2	.	.	.	.	.
04AUG	18:06	6.50	2	D	8.8	.	.	1	.	1	.	.	.
04AUG	18:20	6.50	4	D	6.8	.	.	29	.	.	.	.	.
04AUG	18:55	6.50	1	D	6.2	.	1	8	.	.	.	.	.
04AUG	19:25	5.00	3	D	7.1	.	.	1	.	.	.	.	.
04AUG	19:38	5.00	2	D	8.0	.	.	2	1	.	.	.	.
04AUG	19:50	5.00	4	D	8.4	.	.	4	.	.	.	.	.
04AUG	20:04	5.00	1	D	5.2	.	.	.	.	.	.	.	.
05AUG	12:45	5.00	3	D	6.9	.	.	.	.	.	.	1	.
05AUG	12:58	5.00	2	D	3.8	.	.	2	.	2	.	.	.
05AUG	13:51	5.00	4	D	7.3	.	.	7	.	.	.	1	.
05AUG	14:11	5.00	1	D	5.1	.	.	1	.	.	.	.	.
05AUG	14:34	6.50	2	D	6.4	.	.	1	.	.	.	.	.
05AUG	14:45	6.50	3	D	6.8	.	.	3	1	2	.	.	.
05AUG	15:00	6.50	1	D	5.4	.	.	1	.	.	.	.	.
05AUG	15:14	6.50	4	D	7.7	.	.	4	.	.	.	.	.
					1202	3	3	222	2	115	2	36	42

[a] Stratum: 1 = right bank downriver, 2 = right bank upriver, 3 = left bank onshore, 4 = left bank offshore

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